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cient head and the splendid promise for its immediate future. All here present will, I am sure, heartily join me in wishing for the university and for its department of chemistry no diminution of the splendid prosperity which has attended the efforts of its excellent administration in the recent past.

WILLIAM MCMURTRIE

*CHEMICAL RESEARCH IN AMERICAN
UNIVERSITIES*

GATHERED here to-day to celebrate the installation of one of our prominent American investigators as director of chemistry in the University of Illinois, we should not do justice to the occasion if our thoughts did not turn to the serious meaning of this event for the future of chemical research in our universities. I have thought to devote the few minutes, during which I shall have the pleasure of addressing you, most usefully to the consideration of some conditions affecting the future of chemical research in our American universities.

Before this audience I need make no lengthy plea of justification for the demand for research work in chemistry in our universities, either on the ground of economic considerations or from the standpoint of our highest ideals, as expressed in the struggle of the human race for enlightenment on itself. As Professor Theodore W. Richards recently said in his inaugural lecture at the University of Berlin:

All the manifold experiences of the human mind are intimately connected with the presence of that which we call material, enlivened by that which we call energy; and the ultimate deciphering of the great mystery of life will depend just as much on the understanding of these as upon the study of the mind itself. Thus modern chemistry should be regarded not only as bringing to medicine and the useful arts its obvious and multifarious contributions, but as occupying also an essentially important place in the realm of intellectual speculation.

After Dr. McMurtrie's address it is unnecessary to say much about chemistry in the field of economics. It is a trite fact now that the industrial and commercial supremacy of Great Britain is threatened most dangerously by the wonderful growth of manufacturing in Germany. Englishmen, noting this in the face of the fact that they themselves are rather favored in the matter of natural resources and wealth, are attributing the great strength of their competitors almost entirely to their splendidly trained army of chemists. A significant fact is that this onward march of the German industries is characterized by much of the same fearlessness and supreme confidence of victory as was its march on the unprepared armies of France forty years ago; and for much the same reason—again, it is splendidly organized—organized in the matter of trained scientists, chiefly chemists; its industrial adversary is not—as yet. Chemistry, in some form or other, enters into the production and manufacture of almost all the great articles of commerce—from the raising of wheat and corn on soils scientifically analyzed and fertilized, to the making of steel and all iron materials, from the preparation of brilliant dyes to that of common leather, from the drugs of our sick days to the food products of our daily life—all can be developed best under the direction or with the help of able chemists, and, what is equally important, all, without exception, are capable of vast improvement under the seeing eyes of the chemist, trained to observe closely, to reason accurately, to think originally, to experiment rigorously—trained, in a word, to do research work. German universities and polytechnic schools are turning out such chemists, doctors of philosophy, by the hundred—men trained to investigation, so that they can improve and develop new ways for

actual work of manufacturing, instead of merely using and transmitting traditions. No branch of industry in Germany need want for such men—their numbers and usefulness are seen best from the fact that a single great factory, the Badische Anilin und Farbenfabrik, had in its employ one hundred and fifty such chemists in 1900. There can be no doubt in the mind of any political economist that a country so thoroughly equipped with scientifically trained chemists and with schools for developing them must have an enormous advantage over competitors that lack both or have them only in lesser degree. But such men can receive their final training at universities only from men who are investigators in their branch of work: the critical attitude of mind, the inspiration to originate, the training to convert the new idea into the new result can come only from men who have thought for themselves and worked out their own problems—from research men in our universities.

American universities are feeling the pressure of a growing demand from our industries for such trained investigators, and with this outside pressure and the inner call to do our share toward the elucidation of the great problems of humanity the last years have also witnessed a rapidly growing and insistent demand for research men to fill important university positions; not every university in recent times has been as successful and fortunate as is the University of Illinois in meeting this need; indeed, there is a very decided shortage of men of proved ability to do and direct investigative work in chemistry, and we may well ask why this should be so and what remedy we have for such a condition in this country. Turning only for a moment to chemical research as it was here twenty-five years ago, the better to understand present conditions, we find at that time only here and there in our

universities a man of note carrying on systematic investigations in chemistry: Remsen at Johns Hopkins, the Gibbsses at Yale and Harvard, Cooke, Hill, Jackson, Morley, Long, Michael and Ward, only a handful of men devoting their lives to chemical research as an article of faith. Universities at that time did not demand that their chemistry professors should be investigators, and they were, as a rule, instead, technical experts, analytical chemists—thorough, capable, honest men, but engaged in as extensive and as profitable commercial work as the head of any commercial laboratory. As a matter of fact, we had then practically only one real university, devoted to graduate work as distinguished from college work, and that was Johns Hopkins, our pioneer American university; although, as stated, graduate and research work were also carried on to some extent at Harvard, Yale and a few other places. The greatest recent impetus to all branches of research, including chemistry, came in this country, in my opinion, from the founding of Clark University with research as its chief and almost exclusive field and from the founding, only two years later, of the University of Chicago with its strong graduate school, strong not only in its faculty, but, unlike Clark, also in its student body. By one great effort at once a great college as well as a university, its founding stimulated the development of the graduate schools in the older universities of the east which were also both colleges and graduate schools; the western universities have more slowly strengthened their graduate work or have just started to give graduate instruction, that is, to do real university work. With the development of our universities, in the last fifteen years of eager growth, chemistry in this country has given us the work of men like Richards, of Harvard, a second Stas on atomic weights,

and in this same subject we still have Morley and also have W. A. Noyes, now of Illinois; in organic chemistry we have Nef of Chicago, with great new ideas powerfully influencing work abroad as well as here, Remsen and his students continuing the work of former years, and again, Noyes; in physical chemistry we have A. A. Noyes in Boston, Franklin at Leland Stanford, Bancroft, Hulett, our enthusiastic friend Kahlenberg at Wisconsin fighting nobly for a lost cause; in inorganic chemistry, Edgar F. Smith, Morse and again Remsen. There are about as many names again which could be mentioned and then our list of really prominent research men in chemistry at American universities would be exhausted—I am not including technical research men. With the older men, there are barely twenty men in all, directing strictly original research work in our American universities, work involving new ideas as well as the preparation of new compounds and salts. The supply is far too small to meet the demand, and in view of the importance of the subject, this condition, unless improved, presents a distinct menace to our educational and economic development. A second significant fact is that with the exception of two or three men working under particularly favorable special conditions, the productiveness of our research men is by no means commensurate with the output of an equal number of men in Germany. An impartial scrutiny of the situation shows unmistakably serious defects in our American conditions which must be removed if chemical research is to flourish here as abroad and if able men are to be attracted in sufficient numbers to a life devoted to research and research instruction.

Contrasting the conditions in German universities with ours, we find the American professor, as a rule, overburdened with an

excessive amount of routine work, consisting of lecturing, laboratory instruction and administrative duties. Some teaching must be considered as essential for the welfare of the investigator: in presenting his subject before a critical student body, he is held to an iron logic, he must ever go to the very foundations of our science and, detecting a weak point here, a missing link, a circle proof, a traditional rut there, his mind continually receives ideas for critical work on the very essence of chemistry. But every profound investigation requires a degree of abstraction and absorption as great as that demanded for creative art. And for such work the best powers of the brain are obviously needed: but, after lecturing two hours or giving laboratory instruction for half a day and attending to innumerable petty administrative details, that best power is gone for the days, and each year is made up of just such days or worse in most of our American universities; the mental alertness, the critical and creative faculties, are wasted on routine work, which to a large extent could be done as well or better by a different type of man. Now, in Germany, as I knew it, the great investigators lectured at most once a day, their laboratory instruction was limited to research students, the instruction of all the other students in the laboratory being left wholly in the hands of other men, able men of rank and training, not inexperienced assistants. Then, only a little over half the year was given to academic work, almost half the year being left, not for recreation—a few weeks sufficed for that—but for that intense, absolutely undisturbed work required for the creating mind.

A second important factor in the productiveness of our American chemists as compared with those abroad is found in the problem of research assistants; the creative imagination of the investigator in chem-

istry must always be held in check, as Richards has said, by experimental realization of the logical outcome of his flights of fancy; but chemical experimentation is one of great minuteness, infinite attention to details and endless preparation. Where the German investigator can have, when he needs them, several assistants, ranking from a newly fledged doctor of philosophy to an associate professor when necessary, a single research assistant in chemistry has until recent years been a rare specimen in America and even now the species is not flourishing—it is being starved to death, by low salaries. From presidents who are chemists down to the least of us, we all have our troubles in securing just one of them; the demand for two would perhaps prostrate the authorities. And yet it would be the economic thing not to limit our investigators to one assistant, for men like Nef, Richards, the two Noyes, can direct half a dozen assistants as well as one, and by the present system their productive years are, to a large extent, simply being wasted. But, unless we secure conditions for a large measure of success and productiveness, chemical research in our universities will never attract our best Americans in sufficient numbers to satisfy the minimum demand of our country for able investigators in academic and in industrial lines—and that is the point of my argument.

The last condition I ought to refer to in this connection is one that has caused a wide-spread sentiment of uneasiness in all our universities—the question of the financial side of an academic existence. This serious question, common to all branches of academic research work, is receiving careful attention from our ablest university presidents, and I will leave it entirely in their wiser hands. It is an important factor in regard to the very point raised, the necessity of attracting our able young

manhood to supply the country's need of investigators.

I have tried to point out what I consider the three most essential needs for the development of American chemical research on a plane worthy of our country, on a plane which will enable it to do its share towards the intellectual progress of our race and which will also prepare it for the great commercial struggle of the future: relief of the investigator from an untoward burden of routine and administrative duties; the exploitation of the talents of these gifted men by the employment of a proper staff of research assistants; a proper remuneration, that worry for the future of his family—he cares, as a rule, little for himself—may not impair his usefulness.

The University of Illinois, in selecting a man with the ideals and the capacity of William A. Noyes to develop its work in chemistry, has definitely joined the ranks of those universities which are committed to the attempt to give the highest kind of instruction in chemistry, instruction which will turn out, not artisans, but artists—chemists. In bringing Dr. Noyes here, the university has, as I understand it, wisely kept in mind as far as possible the three conditions for successful work which I have tried to outline. The University of Chicago greeted with the greatest satisfaction the selection of your excellent president to be the head of this institution; we knew he would strengthen Illinois, that he would undertake to raise its standards to those of the best universities of all countries; we rejoiced, not only unselfishly in the satisfaction of seeing the promise of a noble work, but also selfishly; for the higher the ideals of our neighbors, the higher must be the plane of our own lives—in institutional life as in private life. In the same way, I would say on behalf of the chemists of the University of Chicago that we heartily welcome the promise of a strong

department of chemistry here; many links of friendship already bind our faculties; our joint efforts to advance the ideals of chemical research and instruction will surely cement still closer these ties!

JULIUS STIEGLITZ

THE UNIVERSITY OF CHICAGO

*TEACHING OF CHEMISTRY IN STATE
UNIVERSITIES*

A NEW epoch in chemistry has begun in the United States. Development along the lines of pure, industrial and applied chemistry is everywhere evident. The interest now taken by our universities, by our great industries and especially by our national government, bears evidence of wonderful progress. During the past decade, however, the Americans have asked themselves why other countries which can not be compared with our own in wealth and natural resources have surpassed us in nearly every phase of manufacturing and industrial chemistry. Indeed we can not understand how it has come about that the United States, by far the richest country in the world, is so far behind Germany in nearly all lines of manufacturing chemistry.

To one familiar with the European and especially the German industries, the answer seems comparatively simple, depending upon only a few principles, some of which I wish to briefly preface at this time. Germany leads the world in chemical industry, because of her persistent scientific study of every phase of industrial work. For nearly a century her watchword has been "science, industry and economy." She has spent all of her energies along applied chemical lines, and has brought to bear every possible resource which could be utilized in the furthering of her manufacturing conquests. She has long since realized the fact that to take an active part in the industrial world power, she must

match her science against the wealth and natural resources of other rich countries like our own. That she has succeeded is borne out by a glance at her export statistics.

By far the most important factor in the development of the chemical industries in Germany has been her universities. The German universities have perhaps cost the nation more than any other one institution, except her army. Unlike German militarism, however, the universities have been the best financial investment the nation has ever made. For two hundred years these great universities have been the nerve centers, yea, even the very brains, of the whole nation. During the last century they have played a unique and important part in this wonderful industrial development. Without them, her mineral industries would not be worth a passing consideration. Without them, her coal-tar, her beet-sugar and scores of other great industries would, in all probability, barely exist to-day. Without them, Germany would still be a fourth instead of a first class industrial power. Without them, I doubt if the nation could have lived through the fierce storms which have, from time to time, swept over the empire. Without losing the dignity of the university, without losing the highest ideals of scholarship, they have joined the purely scientific with the commercial side of the nation, bringing about conditions which have completely changed the life, the financial and social conditions, of the nation. This wonderful change has been brought about as Van't Hoff has well said, "entirely by a hearty cooperation between the scientific laboratories of the nation and the technical and industrial work."

But other nations have universities. Why have they not done for their respective countries what the German universities have done for Germany? The United